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ABSTRACT

Data reexamination is a critical component for any study. The complexity of the study, the time available for data base development and analysis, and the relationship of the study to educational policy-making can all increase the criticality of such reexamination. Analysis of the error levels in the National Institute of Education's Instructional Dimensions Study (IDS) revealed inconsistencies between the data gathered in the field and the data finally analyzed in the study. Most of these problems were traced to processing errors that could have been corrected before the data were analyzed. The results of the IDS data base reexamination indicate that spending additional time and effort to assure accuracy of the data processing techniques could have saved time and effort by eliminating the need to search for problems. This document briefly describes the basic purposes and the technical design of the IDS to clarify the processes used in this instance of data reexamination. Three examples of error-finding and error-solving are included. (Author/PGD)

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Data Base Reexamination as Part of IDS Secondary Analysis

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Data Base Reexamination as Part of IDS Secondary Analysis

Introduction

The reexamination of a major study data base to verify that the data analyzed are the data that were collected could easily be viewed as mundane. However, when issues of national policy are at stake or when the data base is so large and complex as to increase the likelihood of error between data recording in the field and the final analysis data base, or when the time available for processing and analysis is short, data verification does become a critically important task. The IDS has such policy significance and did result in a large complex data base, compiled in an inordinately short time.

This paper describes the reexamination of the IDS data base as part of an overall secondary analysis effort. Specific changes or corrections in the IDS data base as it existed at the end of July 1977 are not the main focus of the paper. It is hoped that the reader will gain an explicit understanding of the importance of this phase in any study, an insight into the need for effective planning and development of edit procedures, and some overall guidelines for use in other studies.

Background

The Instructional Dimensions Study was funded by the National Institute of Education (NIE) as part of the Compensatory Education Study, a comprehensive NIE research program conducted in response to a mandate by the U.S. Congress in the Education Amendments of 1974. The implementation of this study took place from March 1976 through July 1977 and was conducted by a consortium headed by Kirschner Associates, Inc. (KAI) of Washington, D.C. KAI was responsible for the overall conduct of the study, collected all field data, and performed all computer processing of raw data which resulted in the IDS data base available to the secondary analysis effort. Other members of this consortium included:

- Education TURNKEY Systems, Inc. of Washington, D.C. -- analysis subcontractor to KAI;
- Learning Research and Development Center at the University of Pittsburgh -- design and technical assistance to KAI; and
- Steiger, Fink and Kosecoff, Inc. of McLean, Virginia -- assistance to TURNKEY in the initial design and development curriculum analysis procedures used in the study.

IDS was designed and implemented as a large-scale in-depth assessment of the relationship between selected instructional constructs and students' outcomes with emphasis on achievement (Cooley and Leinhardt, 1975). These constructs are briefly defined below:

- Individualization -- matching of students and curriculum, testing practices, assignment and grouping practices, alternative learning

routes, sequencing and pacing of instruction;

- Opportunity -- amount of time available for instruction and learning, overlap between achievement tests and what is taught;
- Motivation -- interpersonal and/or curricular;
- Instructional Events -- classroom management vs. cognitive teaching behaviors relative to the group size being taught, and the nature of teacher interactions with students; and
- Teacher Background -- teaching experience, formal education, and recent specific training.

In addition to student outcome data and data on these five constructs, information on instructional settings for compensatory education, costs, services provided by school districts, and the criteria used by districts to determine compensatory education eligibility and participation for school buildings and students was gathered.

The analysis samples were obtained from 90 school buildings in 14 schools districts, with approximately 400 classroom teachers, 230 compensatory education teachers, and 12,000 students. Pretests of student achievement and attitudes were conducted in September and early October 1976, and posttests were administered in April and early May 1977. In the fall of 1977 follow-up testing was conducted by KAI for a sample of IDS students to examine changes in achievement scores over the summer of 1977.

The IDS secondary analysis effort being conducted by TURNKEY since August 1977 encompasses a series of related tasks designed to explicate relationships within the IDS data base more fully that was possible during the primary phase. Originally intended as an initial task leading to further analyses of

specific issues, data base reexamination was to include cleaning and reorganizing of the IDS data base as available at the beginning of August 1977. Specific issues intended for further study included: more detailed study of instructional setting, relating grouping heterogeneity to student outcomes, isolating characteristics of effective teachers, exploring additional student or process outcomes, studying the influence of analysis methods on study findings to date, and developing alternate models for prediction of outcomes.

The size and complexity of the IDS data base and the severity of some of its data problems have caused this initial task to require much more attention than was originally envisioned. The scope of this task and its impact on already published preliminary IDS results became the impetus for the present paper.

IDS Data Base as of July 31, 1977

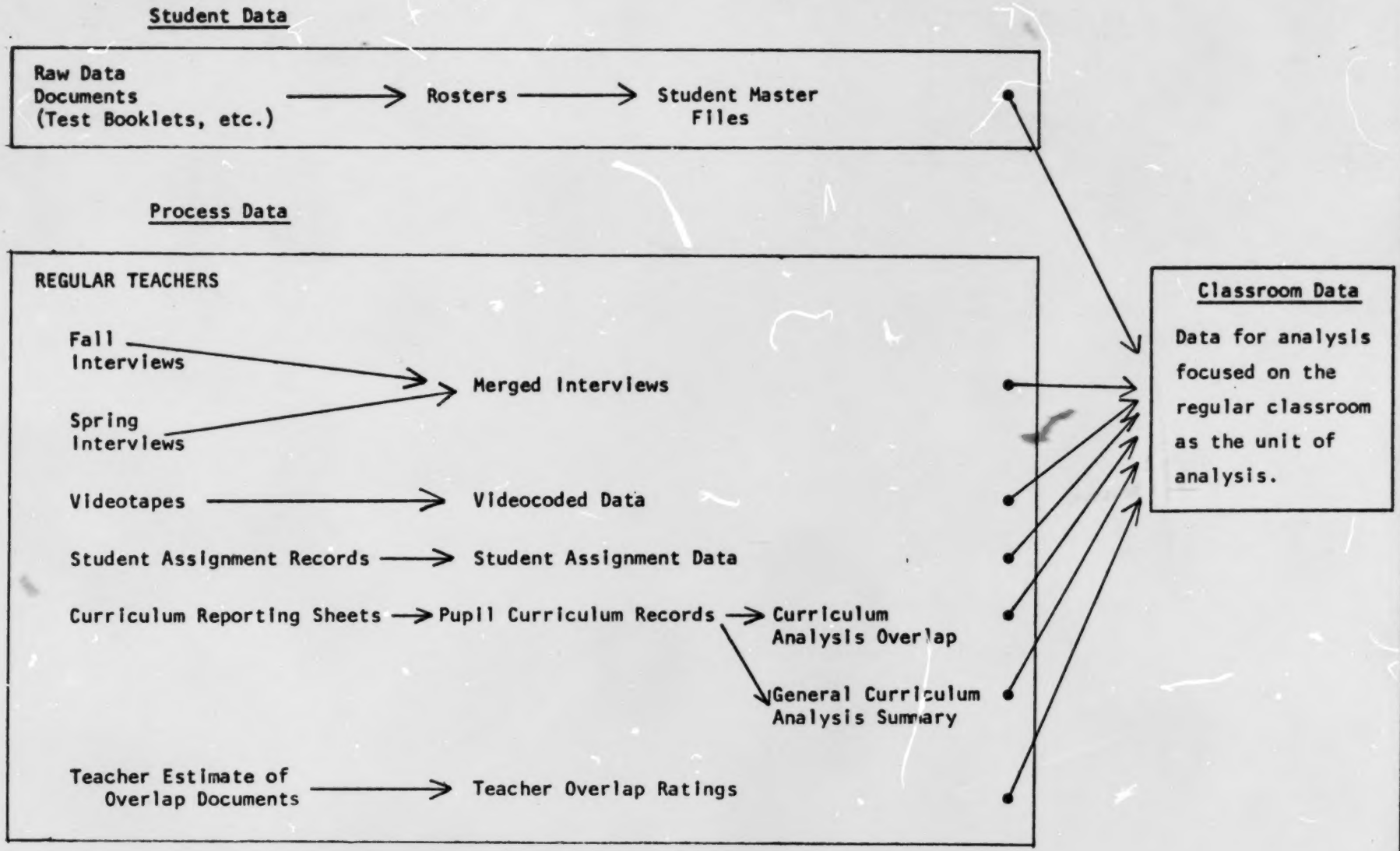
Exhibit I provides a schematic flow chart of IDS student, process, and other data files. A total of 20 magnetic computer tapes containing records for all files shown in Exhibit I except those related to the Curriculum Analysis Overlap and the General Curriculum Analysis Summary were transferred to TURNKEY by KAI at the beginning of August 1977. All raw data documents (test booklets, teacher interviews, etc.) were also transferred to TURNKEY at that time. The two curriculum analysis files mentioned above remain in storage on KAI data disk storage units, since their storage method precludes easy transfer to tape. All videotapes have been stored at TURNKEY since the spring of 1977.

IDS student data files include student-level data on: regular and supplemental instructor, time spent in regular and supplemental instruction, attendance, compensatory education status, attitude (pre and post), number of items in posttest overlapped with curricular experience, achievement (pre and post) by subject subtest and total subject. The Roster File groups students as they were tested; the Student Master File groups students by regular instructor and (for each regular instructor) by supplemental instructor. The Student Master File serves to define both analysis units used for the study: classroom and instructional unit.

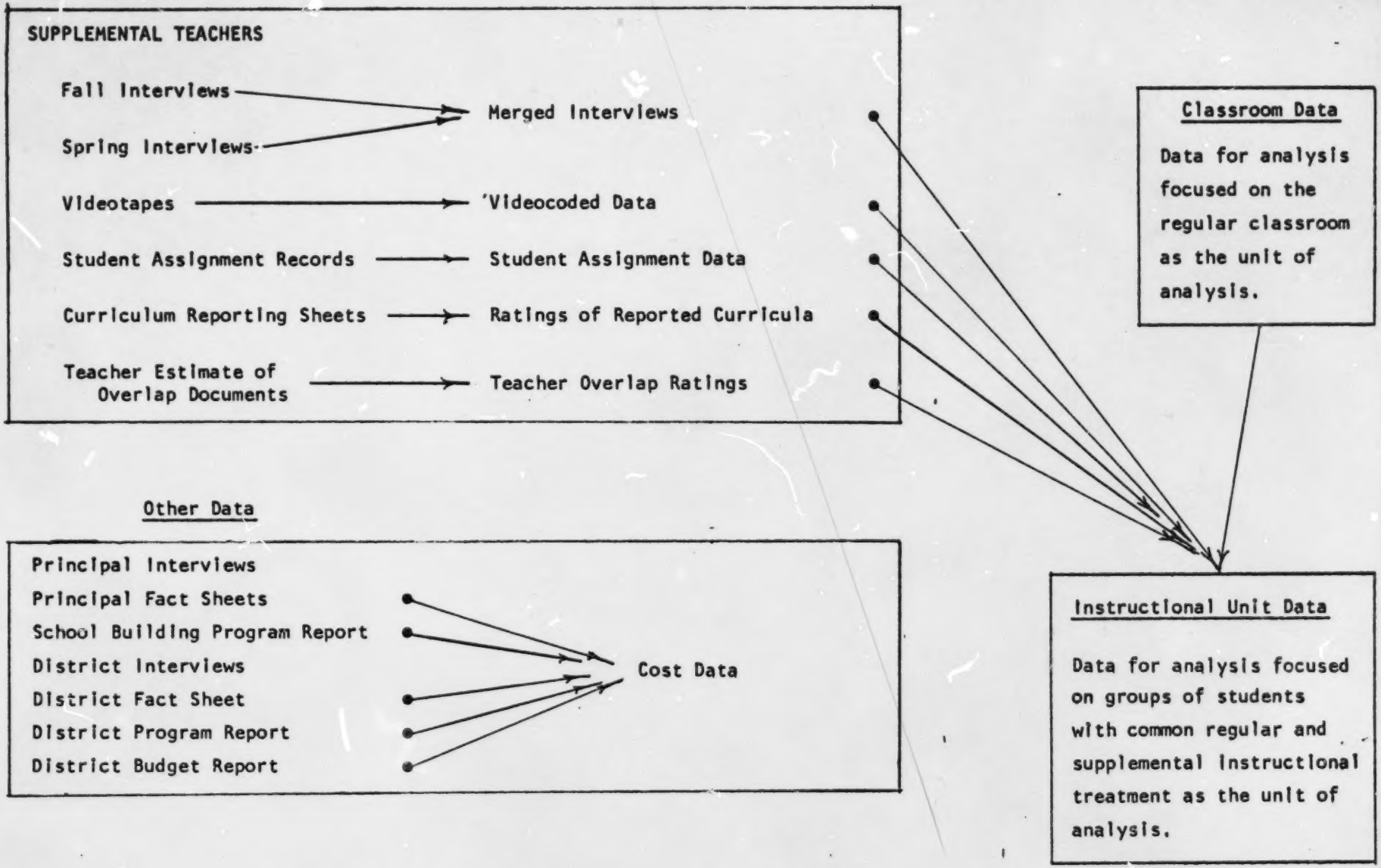
The classroom analysis unit includes student data from all students having the same regular instructor. Process data for the instructor are brought together with the student data to complete the classroom data files.

Exhibit I

IDS Data Files



(Exhibit I continued)



-7-

The "instructional unit" analysis unit (i.e., a sub-classroom unit of analysis) includes student data from all students having both a common regular instructor and a common supplemental instructor. Process data for these two instructors (one regular and one supplemental) are combined using a weighting procedure and merged with the student data to complete the instructional unit data files.

IDS process data files include items covering all aspects of the process constructs described briefly in the Background section. The sources for these data include: teacher interviews, student assignment records, videotapes of classroom experiences, curriculum information (both classroom and student level), and estimates of test/curriculum overlap made by the teachers at the time of posttests in the spring of 1977.

Other IDS data include school and district level interviews, reports, budget documents, program planning documents, and other information relevant to the issues of compensatory education eligibility and participants, program costs, and district poverty/wealth statistics.

Exhibit I clearly demonstrates the complexity of the overall IDS data base. The discussion in the Background section indicates the large size of the data base and underscores the national policy importance of the issues addressed by IDS. Since all final processing of the key analysis files had to be completed between posttesting which ended in May 1977 and the end of July 1977, all three elements outlined in the introduction are present to justify some sizeable effort to verify that the data analyses reported by the IDS study team (Brady, Clinton, et at, 1977) and by NIE (NIE, 1977) were indeed based upon the data actually collected.

Initial Reexamination

The basic intention of initial reexamination activities undertaken as part of the IDS secondary analysis was to compare data residing in last-stage (just prior to analysis) data files to raw data documents in order to verify that the data analyzed corresponded with the data collected in the field. From Exhibit I it can be seen that the instructional unit data file is the eventual receptable for all process data after coding, keypunching, merging, sorting, combining, weighting, etc. have been accomplished. Actually, further data processing for analysis purposes was done using the instructional unit data file, but from that file onward the form of the data (converted to standard z-scores and summed to create sub-construct scores) and the completeness of the data (some items dropped due to missing cases, etc.) would have resulted in a data verification process both more difficult to accomplish and less complete than the comparison points chosen.

The instructional unit data files contain approximately 240 student and process measures for each unit. The student and process data files of Exhibit I provide the scores for each of these instructional unit measures; the positioning of these 240 measures in the instructional unit data file is according to (a) process construct and (b) student data type. IDS instructional unit data files contain data for 334 units for first grade reading (R1), 239 for first grade math (M1), 352 for third grade reading (R3), and 289 for third grade math (M3).

For purposes of data verification systemmatic random sampling techniques were used to select a 5% sub-sample from each of these four data files

(R1, M1, R3, M3). The instructional units within their respective files were arranged in ascending order (by instructional unit identification number) and identified by number (from 1 to n, where n is the number of instructional units in each file). Using a random number table, a unique starting point for each sample was selected from the first twenty records. Using the starting point as the first of the units to be included in the data verification sample, every twentieth record thereafter was also included. A total of 17 units were thereby identified from the R1 file; 12, from M1; 18, from R3; and 15, from M3.

Using available raw data documents, and definitions for the measures of the instructional unit data files, instructional unit measures were calculated and the results compared to the data value resident in the instructional unit data file for that measure. Error bounds used were: $\pm$ 1% of the maximum score for measures having a fixed maximum value, and $\pm$ 2% of the full file average for measures having no fixed maximum value. Choice of this specific definition of error bound was arbitrary, but intended to be fairly stringent.

Not shown explicitly in Exhibit I is the fact that the last-stage data file where an individual student's scores may be identified for verification purposes is the Student Master File. Since hand scoring of student test booklets was used for verification of student scores, it was felt that rescoring of all test booklets for each instructional unit in the verification sample would be too costly. Thus, a phased sampling technique was adopted whereby, once an instructional unit was selected for the overall verification sample, a sample of 2 or 3 students within that unit was used for student score verification. The comparison points

for student scores were hand scored results from test booklets versus Student Master File data values. Achievement pretest booklets were not available, since these had been returned to the participating districts. However, card image records of the item responses for these pretests were available, and these were used in place of the booklets themselves, thereby limiting the assessment of pretest file data validity to keypunch accuracy at best (not a debilitating limitation since observed keypunch accuracy throughout the IDS data files has been up to accepted commercial standards). Error bounds for student scores were $\pm$ 1 test item. Again, choice of this definition of error bound was arbitrary but intended to be stringent.

Results of these initial reexamination activities indicated a substantial number of process measures (111 measures) having errors in 5% or more of their verification sample values. Additionally, student score verification activities indicated that approximately 20% of the third grade students examined from the verification sample had errors in posttest achievement scores in excess of the $\pm$ 1 test item bound. Also, it was found that 6 to 12% of all students had errors in pretest attitudes scores in excess of the $\pm$ 1 test item bound. Finally, it was also found that 29% of the M1 students examined for the verification process had erroneous compensatory education status data. First grade achievement posttests, all achievement pretests, all attitude posttests, and all compensatory education status data except for the M1 file were found to be acceptable.

Detailed Reexamination

Once the initial reexamination was completed it was apparent that the scope of the indicated problems required a greater scrutiny. Thus, the first result of the initial reexamination was the realization by TURNEKY and NIE that reallocation of resources away from desired analysis tasks to the detailed reexamination of data would be necessary.

It was also clear that in order to preserve as much of the current study's available resources for analyses, it would be necessary to prioritize the problem areas in some manner. A plan was adopted for assigning resource priorities that included the following steps:

1. Focus only upon those process measures or student data areas identified in the initial reexamination;
2. For each of these measures, view the units in the verification sample in two distinct categories: (a) those whose values fall within the error bounds and (b) those whose values do not;
3. For the (b) category determine the average size and direction (algebraic sign) of the observed errors and determine the average absolute error size;
4. Project these results to the full file by means of the following formulae:

$E_s = (1-P)(e_s)$ and $E_a = (1-P)(e_a)$ where

P = proportion of the verification sample falling into category (a); i.e., having acceptable data

e_s = average algebraic error size for category (b) units

e_a = average absolute error size for category (b) units

E_s = projected full file average algebraic error

E_a = projected full file average absolute error;

5. In order tc compare projected full file errors across measures having basically different scales, express the E_s and E_a values so calculated as a percent of the maximum scale values for those measures having such a fixed maximum or as a percent of the average full file value for measures having no fixed maximum; and
6. Rank order the measures according to the resulting percentages.

These steps can best be summarized by saying that the priorities for attention should go toward those measures whose observed errors would have the largest impact on analysis, where impact is expressed as a percent of some scale value.

An illustration may be helpful here. Suppose 80% of verification sample units indicate acceptable values for Measure A, 60% for Measure B. Measure A has a fixed maximum scale value of 100; Measure B has no fixed maximum, but has an average scale value of 75 for the full file from which the verification sample was drawn. The average algebraic error size for the 20% of the sample units showing unacceptable values is +10 for Measure A; for Measure B, this average is +5. The average absolute error size for the units with errors

is 15 for Measure A, 10 for Measure B. Then:

Measure A	Measure B
$E_s = (1-.80)(+10) = +2$	$E_s = (1-.60)(+5) = +2$
$E_a = (1-.80)(15) = 3$	$E_a = (1-.60)(10) = 4$
$(E_s/100) \times 100 = +2.0\%$	$(E_s/75) \times 100 = +2.7\%$
$(E_a/100) \times 100 = 3.0\%$	$(E_a/75) \times 100 = 5.3\%$

In this illustration, Measure B would get priority for correction over Measure A since rank ordering of the resulting percentages shows B in greater need than A whether the focus is one E_s or E_a.

One additional step is needed: application of a cut-off percentage for the values resulting from step 5. IDS secondary analysis efforts have used an arbitrarily chosen value of 4% for measures having a fixed maximum scale value and 2% for measures having no fixed maximum. Also, it has been the case to consider a measure as being a candidate for correction if either the E_s-based or the more stringent E_a-based percentage exceeded the above cut-off values.

The above described steps of assigning priority for resource allocation have been applied to all process measures. As a result a core of 32 measures (of the 111 initially identified) are being subjected to a correction process.

Due to the critical nature of the student data involved (compensatory education status, posttest scores), no priority assignments were made for these variables. Instead all errors were studied. All sources of errors were identified and corrections were made for all major errors except the attitude measure pretests. NIE felt no priority should be assigned to correcting the attitude measures.

The task of identifying the source of the error has been carried out in all cases by tracing the data flow chart (like that shown in Exhibit I) for the point at which the error seems to enter the flow. It is then determined if the error and/or its entry point into the data base is systemmatic, and program corrections from the last point of correct data are instituted. No hard and fast rules can be offered on these steps since each study's data files have their own unique history. But the logic inherent in their development will provide the most powerful clues to the source of the problems and, therefore, to the correction steps needed.

Short histories of three data problem situations will be presented so as to illustrate the conduct of the above tasks in the IDS secondary analysis.

The first situation involves the third grade posttests referenced in the Initial Reexamination section. Recall that 20% of the third grade students examined from the verification sample had errors in posttest achievement scores in excess of the ±1 test item bound. In fact, these unacceptable cases had scores in the Student Master File averaging 21.9 points below the hand scored test results obtained from these students' actual test booklets. The magnitude of this error became the immediate focus in the search for the source of the error. What could cause a child's score to be recorded as only half of what it actually was?

The answer was found in the process followed in obtaining a test score once the booklets were received from the field. Tests were not scored by hand in IDS; rather, the child's response to each question was precoded and keypunched.

These responses, recorded on keypunched cards, were then scored via a computer program. The responses made by the first grade children pre and post and third grade children at pretest were identified in the test booklet by the number (e.g.; 1, 2, 3 or 1, 2, 3, 4) corresponding to the selected answer for each question. However, third grade posttest responses were either numbered, 1, 2, 3, 4, or lettered, A, B, C, D, for each odd numbered test question in a subtest, but the even numbered questions used the numbers, 5, 6, 7, 8, or the letters, E, F, G, H. All keypunched responses were coded as numbers with the codes being assigned as follows:

	THIRD GRADE CHILD'S RESPONSE	KEYPUNCH CODES
odd-numbered questions	1 or A	1
	2 or B	2
	3 or C	3
	4 or D	4
even-numbered questions	5 or D	5
	6 or F	6
	7 or G	7
	8 or H	8

Before being sent to keypunch all test booklets were coded onto 80-column record layouts. What if a certain coder used the conversions for odd-numbered questions for the even-numbered items on the third grade posttest in some cases? Then the scoring algorithms would erroneously indicate that all even-numbered questions had been answered uncorrectly. The unacceptable cases were examined in light of this hypothesis, and the hypothesis proved correct. Coding sheets for these cases verified the erroneous coding entries.

And since all coding sheets for third grade posttests were available, project staff were able to isolate all cases of this problem. Fortunately the sample used in the initital data base reexamination proved unrepresentative of the total IDS sample; only 10 classrooms out of 200 were actually involved. Test scores for these children were corrected, thereby eliminating the only major error found related to achievement test scores. This situation could have been avoided by more thorough edit procedures.

The next situation involves the M1 compensatory education status data also referenced earlier. Recall that 29% of the M1 students were found to have errors in their status as indicated in the Student Master File. Before the initial reexamination had revealed this error, questions had been raised within the study team over the large number of students assigned a compensatory education status in the M1 file. The number of such students in the M1 file matched very closely the number of R1 compensatory education students. NIE's report on Compensatory Education Services (July 31, 1977) indicated that nationally only about half as many students participated in compensatory math programs as do in compensatory reading programs. This ratio was evidenced at the third grade, leaving the first grade data in even stronger doubt. What if a student's recorded status in the M1 file was not a math status at all but instead was his or her reading compensatory education status? This hypothesis would explain the apparent overabundance of compensatory education students in the M1 file. This was indeed the problem. When creating the M1 student files students' R1 status had been erroneously entered. None of the M1 students in the verification sample had correct data for compensatory status; 71% happened to have a M1 status that in fact agreed with their R1 status. This error also was corrected.

The final situation involves a set of process errors identified after the application of the six steps described earlier in this section. All of the process measures derived from the student assignment documents (Today's Assignment Sheets or TAS) were found to have excessive error rates. Using the logical flow chart for these data indicated one source for this problem very rapidly: whenever a teacher was in the study for reading as well as for math instruction, the TAS data for reading was not only carried into the instructional unit data files for reading but for math as well -- another example of a processing error. However, while tracing specific additional errors identified for individual teachers, several cases of duplicate TAS records were found in the TAS data file; i.e., two records with differing data but the same identical teacher identification number. Following this lead revealed that nearly 10% of the TAS records were, in fact, duplicates. The most common pattern for these duplicate records is one record with the correct identification and correct TAS data plus one or more records with the same identification but blank TAS data. A current hypothesis, not yet verified, is that TAS raw data documents which involved more than one sheet of paper may have been, in some instances, erroneously coded as one record for each sheet. These multi-page instruments had the indentification code on each sheet but had the TAS data values written only on the top sheet. It is possible that in some cases these multi-page TAS documents were coded as if each sheet were a separate record. Corrections to these TAS data are in progress.

Activities Developing from Data Reexamination

Corrections to student data have been completed and the Student Master Files have been rebuilt and restructured to include additional keys for tying IDS student level data to all aspects of the IDS data base, additional overlap data, and revised student-level instructional time data which reflect actual student attendance.

Corrections of the key process errors identified are in progress. For some a specific source has not been found, so reprocessing will be done from the raw data level. For others sources have been located and the corrections are being made.

The impact of the corrections in student data is dramatic in some cases. As an illustration, Exhibit II is taken from the NIE report of September 30, 1977 (The Effects of Services on Student Development). This exhibit presents fall and spring achievement test scores for compensatory education students in the overall study sample (as printed on p. 20 of the NIE report). Exhibit III presents the revised results corresponding to Exhibit II based on the corrected student data.

Comparing Exhibit II and III shows that the large gains for IDS compensatory education children referenced in the NIE report are actually even larger than originally thought. It should be noted that changes in the sample sizes at all grade levels are brought about by the corrections referenced above and by some additional compensatory education status corrections identified as a by-product of the correction process itself.

Exhibit 11

FALL AND SPRING ACHIEVEMENT TEST SCORES FOR COMPENSATORY EDUCATION CHILDREN IN THE IDS SAMPLE (FROM NIE REPORT)*

	n	(Mean) Raw Score Fall	Spring	Gain
Reading 1	1,355	23.8	47.4	23.6
Mathematics 1	1,429	15.6	27.3	11.7
Reading 3	1,406	19.7	31.0	11.3
Mathematics 3	792	21.3	36.7	15.4

*National Institute of Education. The Effects of Services on Student Development, Washington, D.C.: U.S. Department of Health, Education, and Welfare, September 30, 1977.

Exhibit III

FALL AND SPRING ACHIEVEMENT TEST SCORES FOR COMPENSATORY EDUCATION CHILDREN IN THE IDS SAMPLE (REVISED RESULTS)*

	n	(Mean) Raw Scores Fall	Spring	Gain
Reading 1	1,415	23.8	47.6	23.7
Mathematics 1	630	15.5	27.4	11.8
Reading 3	1,542	19.7	31.7	12.0
Mathematics 3	830	21.4	38.6	17.2

*As of 3/14/78; based on work performed under contract No. NIE 400-77-0065

Exhibit IV, taken from the NIE report, compares the achievement of students receiving instruction in mainstream programs to those from pullout programs (as printed on p. 23 of that report). Exhibit V presents the revised results corresponding to Exhibit IV.

Comparing Exhibits IV and V shows an even more dramatic effect of the student data corrections. In its report NIE indicated that neither setting (mainstream vs. pullout) appeared to be consistently associated with greater instructional effectiveness. Exhibit V does not support this assertion; mainstream gains are significantly greater in three of the four comparisons with no significant difference in the fourth.

Exhibit IV

FALL AND SPRING ACHIEVEMENT TEST SCORES FOR COMPENSATORY EDUCATION CHILDREN RECEIVING SETTINGS (FROM NIE REPORT)*

		(Mean) Raw Scores		
	n	Fall	Spring	Gain
Reading 1				
Mainstream	311	24.3	51.3	27.0
Pullout	1,044	23.6	46.3	22.7
Mathematics 1				
Mainstream	1,172	15.7	27.9	12.1
Pullout	257	15.6	24.4	8.8
Readint 3				
Mainstream	195	19.4	29.4	10.0
Pullout	1,211	19.8	31.2	11.4
Mathematics 3				
Mainstream	170	20.5	32.5	12.0
Pullout	622	21.5	37.9	16.3

*National Institute of Education. The Effects of Services on Student Development. Washington, D.C.: U.S. Department of Health, Education, and Welfare, September 30, 1977.

Exhibit V

FALL AND SPRING ACHIEVEMENT TEST SCORES FOR COMPENSATORY EDUCATION CHILDREN RECEIVING INSTRUCTION IN PULLOUT OR MAINSTREAM SETTINGS (REVISED RESULTS)*

		(Mean) Raw Score		
	n	Fall	Spring	Gain
Reading Grade 1				
Mainstream	309	24.3	51.4	27.1
Pullout	1106	23.7	46.5	22.8
Mathematics Grade 1				
Mainstream	307	15.4	29.1	13.6
Pullout	323	15.6	25.7	10.1
Reading Grade 3				
Mainstream	198	19.4	34.3	14.9
Pullout	1344	19.8	31.3	11.5
Mathematics Grade 3				
Mainstream	165	20.6	37.7	17.1
Pullout	665	21.6	38.8	17.3

*As of 3/14/78; based on work performed under contract No. NIE 400-77-0065

Summary

Data reexamination is a critical component for any study. The complexity of the study, the time available for data base development and analysis, and the relationship of the study to educational policy making can all increase the criticality of such reexamination. A general guide would say: before believing too strongly in the indicated results of a study, look back and ask if the data analyzed correspond with the data collected in the field. Understand and use the logical data flow patterns of the study in this reexamination.

Draw from all available sources. The IDS secondary analysis effort has included both organizations (KAI and TURNKEY) involved in the implementation phase of the study. Only through the combined effort of all study personnel have the problems been identified and, most important, solved.

Hold onto as much time as possible for the data processing and analysis phase of the study. IDS and NIE time constraints left less time for these tasks than is normally desireable. But, whatever time is available should be effectively utilized by reliance on pre-tested and thoroughly applied edit routines.

Be prepared to prioritize data examination/correction efforts if more problems are found in the "look back" than anticipated.

Overall, remember that neither elegant statistical techniques nor a strong analysis model can overcome erroneous data.

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